than what one might have expected, is the very great distance to which the point 1 descends at ordinary temperatures. It would be interesting to compare the forms of these parts of the curve for several liquids, and see whether there was any connexion between it and the capillarity.

III. "The Influence of Stress and Strain on the Physical Properties of Matter. Part III. Magnetic Induction." By

HERBERT TOMLINSON, B.A. Communicated by Professor W. GRYLLS ADAMS, M.A., F.R.S. Received March 17, 1887.

(Abstract.)

The author lays before the Society the results of experiments extending over a period of ten years on the effects of stress and strain on the magnetic permeabilities of iron, nickel, and cobalt.

Two methods were employed. In one the metal to be tested—usually in the form of wire—was placed with its axis coincident with that of a magnetising solenoid, in most cases of considerable length as compared with the diameter of the wire; round the central portion of the solenoid was wrapped a secondary coil. A similar pair of primary and secondary coils, with a similar piece of the same specimen of metal, was balanced against the first by means of resistance coils, so that on closing the magnetising circuit no deflection was produced in a delicate Thomson's galvanometer suitably connected up with the resistance coils and secondary coils. The alteration of magnetic permeability produced by stress was measured by the change necessary to be made in the resistance coils in order to restore the balance.

In the second method the resistance coils were dispensed with, and only a metal core used in one of the two pairs of solenoids which were connected in series each to each. The arrangements were such that the pairs of solenoids, when without any cores, balanced each other's effects on the galvanometer, so that the deflections of the latter instrument were due only to the magnetic permeability of the metal to be tested. The alteration of permeability was in this case measured by the change of deflection produced in the Thomson's galvanometer. The second method was the one principally employed.

In all cases, where it is advisable, the results are either given in C.G.S. units, or data are supplied for reducing to these units; moreover, the author has endeavoured to separate, as far as possible, the effects of stress on the *permanent* and on the *temporary* permeabilities of

the metals,* which effects are for the most part opposite in nature. The paper is illustrated by a large number of curves showing the relations between magnetic permeability and stress and strain at different temperatures from 0° C. to 300° C. and upwards. The information conveyed by these curves it is impossible to adequately represent in an abstract, but the following are among the chief conclusions arrived at:—

1. When there is no permanent load on an iron wire, and the magnetising force is small, longitudinal traction of small amount increases the temporary permeability. The increase reaches a maximum very quickly, as the load increases when further loading begins to diminish the magnetic permeability, until a certain limit has been reached, for which the permeability is a minimum. If the load be carried beyond the above limit the permeability begins to increase again with the load. As a consequence of the above, when the magnetising force is small there are *two* critical values of load for which the load produces no effect on the temporary permeability.

2. The first of the two critical values of loading mentioned above diminishes with increase of magnetising force, and finally vanishes when the latter reaches a certain limit.

On the contrary, the second critical value of loading increases with the magnetising force.

3. The maximum of temporary permeability mentioned in 1 diminishes as the magnetising force increases, and occurs at a less and less degree of loading until the latter begins to produce decrease instead of increase of permeability.

The minimum of temporary magnetic permeability, on the contrary, increases with the magnetising force, but, like the maximum, occurs with a lower amount of load the higher the magnetising force.

4. The effects mentioned in 1, 2, and 3 as being produced by loading, are modified when a comparatively small load is left permanently on the wire. The modifications are stated in 5, 6, and 7.

5. For small magnetising forces loading produces no effect on the temporary magnetic permeability, unless carried beyond a certain limit. Beyond this limit further loading suddenly begins to increase the permeability.

6. For all values of the magnetising force the first critical value of loading vanishes.

The second critical value of loading increases with the magnetising force, but for a given magnetising force is much lower than when there is no permanent load.

* By the terms permanent and temporary permeabilities are meant the permeability for permanent magnetisation, and the permeability for temporary magnetisation respectively.

7. The minimum temporary permeability increases with the magnetisingforce up to a certain limit of the latter, but beyond this limit decreases.

8. The permanent magnetic permeability is increased by loading, the amount of increase per cent. being very large for small magnetising forces and moderate loads, but diminishing as the magnetising force increases.

9. The increase of permanent magnetic permeability mentioned in 8 rises in greater proportion than the load up to a certain limit of the latter. Beyond this limit it rises in less proportion than the load, and eventually ceases to rise with increase of load; the value of the load at which this last occurs decreases as the magnetising force is increased.

10. For a wide range of loading, the effect of the stress on the permanent permeability is opposite in direction to the effect on the temporary permeability. Consequently loading may be found to produce either increase or decrease of permeability according as the permeability we are considering is temporary or permanent.

Similarly the total magnetic permeability, since it includes both temporary and permanent permeabilities, may be affected by loading in the contrary direction to the temporary magnetic permeability, and the more so as the effects of loading on the permanent magnetic permeability are very much larger than those on the temporary magnetic permeability for a rather wide range both of loading and of magnetising force.

11. The effect of loading—even when carried to a great extent—on the temporary permeability of unannealed piano-steel is very small, provided the wire be not permanently stretched by the load.

12. The effect of loading on the magnetic permeability of annealed iron varies very considerably with the amount of previous strain to which the metal has been subjected.

13. When the magnetising force is very considerable and the load small, permanent extension, resulting from previous loading, causes the diminution of temporary permeability produced by the load to be much increased; also the maximum diminution which can be temporarily produced by loading is increased.

When, however, the temporary load exceeds a certain limit, the diminution of temporary permeability produced by the load is lessened by permanent extension. Further, the load which produces maximum diminution of temporary permeability may be considerably lessened by permanent extension.

14. When the magnetising force is small the permanent strain may change *increase* of temporary magnetic permeability resulting from loading to *decrease*, provided the load does not exceed a certain limit.

When the above-mentioned limit is exceeded the effect of the permanent strain is reversed.

15. The effects mentioned in 12, 13, and 14 are for the most part really the results of *subpermanent molecular strain*, and can be in great measure removed by severely shaking the wire.

16. The permanent molecular strain which is left on the removal of any load, produces, both for low and high magnetising forces, a permanent diminution of magnetic permeability increasing with the strain up to a certain amount of the latter. When, however, the strain is such that the wire is sensibly increased in length, the *temporary* permeability *increases* considerably, and the *permanent* permeability *diminishes* considerably up to a second limit of permanent strain, when once more *decrease* of temporary permeability sets in.

17. The first maximum of the decrease of permeability mentioned in 16 at first decreases with increase of the magnetising force to nearly zero; it increases again, however, if we exceed a certain limit of magnetising force.

On the contrary, the maximum increase of temporary permeability at first rises with the magnetising force until the permeability is more than doubled, when it begins to fall as the magnetising force is pushed further.

18. Mere rest after permanent extension has little or no effect on the alteration of the temporary permeability which is produced by loading, whereas it very perceptibly increases the longitudinal elasticity of iron.

19. For magnetising forces not exceeding a certain limit there are, for all temperatures between 0° C. and 300° C., two critical values of loading for which no alteration in the temporary permeability is produced by the load (see 1).

The value of the load at the first critical point diminishes, and that at the second critical point increases, as the temperature is raised from 0° C. to 100° C. but as the temperature is raised still further the first critical load becomes greater and the second becomes less, until at some temperature between 250° C. and 300° C. the two critical points coincide.

20. For magnetising forces exceeding a certain limit the two critical points of loading approach each other, at first slowly and then rapidly, with increase of temperature from 0° C. to 300° C. Both critical loads diminish with rise of temperature, but the second more rapidly than the first.

21. The effect of loading on the permanent permeability diminishes with rise of temperature from 0° C. to 300° C.

22. As the magnetising force increases, the total magnetic permeability of annealed iron which has not been previously magnetised rises to a maximum and then begins to decline. The maximum permeabi-

lity seems to occur at nearly the same point of magnetic *intensity* for different specimens of well-annealed iron of good magnetic permeability, but not at the same point of *magnetising force.*

23. When an iron wire has received previous magnetisation the point of maximum permeability occurs with a higher and higher magnetising force as the previous permanent magnetisation increases.

The point of maximum permeability also occurs at a higher degree of magnetic *intensity* when the wire has been previously subjected to a high magnetising force.

24. Besides a point of maximum total permeability there is a point of maximum *temporary* permeability which occurs a little before the first-mentioned point.

24 and 23 are in accordance with Maxwell's extension of Weber's theory.

25. The temporary permeability is diminished by previous permanent or subpermanent magnetisation in the same direction. The effect above mentioned may be very considerable, provided the magnetising force lies between certain limits.

26. When the wire is well shaken after having been previously magnetised by a strong force the temporary permeability is considerably restored, and is, moreover, much more nearly a constant for different values of the magnetising force than it was either previously to shaking or previously to suffering permanent magnetisation.

27. More than 90 per cent. of the whole magnetisation imparted by a given force to annealed iron may be permanent or subpermanent provided the magnetising force has a certain moderate value.* When, however, the force is very large the percentage of permanent magnetism is much diminished.

28. When an iron wire is loaded to a certain limit longitudinal magnetisation has no effect on the thermo-electrical qualities of the metal.

The limit of loading mentioned above seems to be the same for a given magnetising force, as that at which magnetisation has no effect on the dimensions of the wire.

29. The general features of the curves showing the relation between temporary magnetic permeability and load are the same for nickel as for iron.

30. There are two critical points of loading at which the load has no effect on the temporary magnetic permeability of nickel.

31. The load at the first critical point diminishes with diminution of the magnetising force and finally vanishes.

* This has been already noticed by Ewing ('Phil. Trans.,' 1885, Part II), in whose important memoir other points of interest connected with magnetic induction which are mentioned in this paper have been also discussed.

On the contrary the load at the second critical point increases as the magnetising force diminishes.

32. The effect of increasing the magnetising force on both the first and second critical loads is therefore opposite in direction to the effect in the case of iron.

33. Similarly the effects mentioned in 3 are opposite in direction in nickel and in iron.

34. Rise of temperature from 0° C. to 300° C. increases the maximum increase of temporary magnetic permeability, which can be effected by loading nickel wire, and diminishes the maximum decrease.

35. With nickel as with iron the magnetic permeability is not constant, but reaches a maximum. The magnetising force which produces maximum permeability is greater with nickel than with iron, but the magnetic intensity at the point of maximum permeability is less with nickel than with iron.

36. Nickel wire can by shaking be more effectually de-magnetised than iron.

37. Well annealed nickel is capable of retaining subpermanently a very large percentage of the whole magnetisation imparted. The maximum percentage retained is, however, not so great as with iron.

38. At a certain temperature the magnetic permeability of nickel vanishes. The temperature at which this occurs seems to be higher the higher the magnetising force. This last, however, may perhaps be due to impurities in the nickel.

39. The magnetic permeability of nickel rises with the temperature to a maximum and then diminishes. The temperature at which maximum permeability occurs diminishes as the magnetising force increases.

40. The temporary effects of compression on the temporary magnetic permeabilities of iron, nickel, and cobalt, are in the opposite direction to the effects of extension, provided neither the mechanical nor the magnetic stress exceeds a certain amount.

41. The temporary effect of traction transverse to the line of magnetisation on the magnetic permeability of iron, is opposite in direction to the effect of traction in the same line as the magnetisation.

42. Temporary torsion beyond a certain limit (see 44) increases the temporary magnetic permeability of iron. The amount of increase may become very large if the wire has previously suffered permanent torsion or permanent magnetisation in the opposite direction.

43. Permanent torsion decreases the temporary magnetic permeability. The amount of decrease may become very large if the

wire has previously received permanent torsion in the opposite direction.

44. There is for all but very large magnetising forces a critical point of torsion, for which temporary torsion does not affect the temporary magnetic permeability.

45. When the critical point of torsion is passed, the temporary permeability increases with the torsion at first more rapidly than the torsion, and afterwards more slowly until a maximum is reached and the permeability begins to decline.

46. When the wire has previously suffered excessive permanent torsion, temporary torsion which has before produced increase of permeability now produces decrease.

47. The effect of temporary torsion on the temporary permeability of unannealed piano-steel wire is in the same direction as with annealed iron which has suffered excessive permanent torsion (see 46).

48. For a wide range of torsion the temporary permeability and the permanent permeability of annealed iron are oppositely affected by temporary torsion.

49. Fluid pressure does not temporarily affect either the temporary magnetic permeability of annealed iron, or the permanent magnetisation of hard steel, except, it may be, to a degree which is not comparable with that of the effect of stress applied in any one direction.

50. The application, however, or the removal of fluid stress like that of the stresses of compression, extension, and torsion, shakes out from annealed iron a certain amount of residual magnetism.

IV. "Note on a New Constituent of Blood Serum." By L. C. Wooldridge, M.D., D.Sc., Research Scholar to the Grocers' Company. Communicated by Dr. Pye-Smith, F.R.S. Received March 19, 1887.

I wish in the present note to draw attention to a proteid substance which exists in very small quantity in blood serum. Owing to the difficulty of obtaining a sufficient amount, I shall not attempt to give a complete description of its chemical characters, but shall confine myself chiefly to its physiological properties which, I venture to suggest, possess considerable interest. It is obtained by rendering undiluted serum distinctly acid by means of dilute acetic or very dilute (4 pro mille) sulphuric acid. Neutralisation does not cause its precipitation; the serum must have a strong acid reaction. It is constantly present in the serum of dog's blood, and when collected by the centrifuge it is precisely similar in physical characters to ordinary